U.S. Department of Agriculture Agricultural Research Service

Jan-Feb 1982

Agricultural Research

Toward Safer, More Wholesome Food

The quality and safety of food that we Americans expect today and have taken for granted for many decades rest on two acts of Congress passed 76 years ago—The Federal Meat Inspection Act and the Federal Food, Drug, and Cosmetic Act.

Since 1906, there has been great progress in improving food quality and safety in all the vital links between farm and consumer. Much of this progress has come from the research of agricultural scientists throughout this country, those that transfer the technology to the users, and the acceptance and implementation of the technology by the agricultural industry and farm community.

Technology to detect spoilage early in the food chain has been of prime importance. Safe storage of food from harvesting through warehousing, transporting, processing, packaging, and exporting is critical. These steps in the food chain, vital to food quality and safety, are usually hidden from the consumer. They are little understood and thus rarely appreciated.

Those involved in the agricultural chain and in research know the impact of spoilage and contamination on consumer health and on the economics of the marketplace.

As research technology becomes more sensitive, we will be able to measure contaminants in parts per quadrillion or perhaps parts per jillion. We will learn which contaminants are available, which pervasive, and which innocuous. Advancing technology may even allow farmers to test food samples simply and accurately on the farm. Food can then be shipped only when safety and wholesomeness are assured.

Today, by means of an infrared sensor, we can detect insects in stored products by the amount of carbon dioxide they exhale. The infrared sensor works in wheat, flour, cornmeal, food mixes, cocoa powder, candy bars, and dried fruit. Soon it may be used in granaries. Eventually it could help reduce millions of dollars of losses in products, which would increase export markets. All this without using chemicals.

Insects can be suffocated in stored agricultural products with harmless nitrogen and carbon dioxide gases. This control method may next be approved for stored processed foods.

Khapra beetles, one of the most persistent and destructive insect pests of stored agricultural products, can now be detected. Although they cannot yet be satisfactorily eradicated, scientists are confident that the beetles will yield to future research.

Ethyl formate, a naturally occurring chemical produced by fruit, is being used to control aphids and thrips on strawberries and lettuce. Because this natural fumigant is 100 percent effective, it is expected to boost exports to the Far East, where shipments are often condemned because of these pests.

New containers have been designed for shipping fruit so that it arrives at its destination in better condition.

Research has contributed a new automated system for cleaning beef carcasses which significantly decreases spoilage caused by microorganisms.

Healthier food animals are now a reality through the control of screwworm in cattle and the control of numerous other animal diseases by vaccines.

These are but a few examples of how our improved technology has added safety and quality to our food. The list is long. We have come a long way since 1906.

Although our foods are safer and more wholesome than those produced anywhere in the world, we must continue to apply our superior technology to improve the food quality and safety in all links of our food chain. Only then will safe and wholesome foods continue as an everyday reality to enhance the quality of our lives.

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Agricultural Research
Vol. 30 No. 7-8
January-February 1982

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Agricultural Research is published monthly by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 15, 1982. Yearly subscription rate is $15 in the United States and its territories, $18.75 elsewhere. Single copies are $2.00 domestic, $2.50 foreign. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

Magazine inquiries should be addressed to: The Editor, Information Staff, Room 3145-S, USDA, Washington, D.C. 20250. Telephone: (202) 447-6161.

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Cover: The unique new U.S. Dairy Forage Research Center north of Prairie du Sac, Wis., is designed to accommodate a research herd of 300 milking cows. The interdisciplinary research program for improving forage and dairy production will be complemented by research at seven state agricultural experiment stations. Story begins on page 4. (1181X1432-8a)

Dairy Forage Research Center

Just north of a little town named Prairie du Sac in one of Wisconsin's scenic areas lies a new farmstead only partly visible from State Route 78 and screened by a border of trees along the Wisconsin River. That's a place where ARS scientists are setting their sights on increasing efficiency of forage production by 10 percent in 10 years to benefit both dairy farmers and consumers.

"Fulfilling this goal may translate into a $500-million-per-year reduction in food costs in terms of today's dollars—a savings that exceeds the entire amount budgeted for ARS throughout the whole country," says Raymond J. Bula, director of the new U.S. Dairy Forage Research Center. And the research is aimed at helping forages compete with corn for a place on land that is sloping and erosion prone.

The Center consists of a dairying operation comprising about 1,300 acres of land—about 2.5 acres under roof—at the Badger Army Ammunitions Plant near Prairie du Sac, and an office-laboratory-greenhouse complex at the University of Wisconsin-Madison campus.

Completed January 1981, the campus facility, which is located just north of the University's historic landmark dairy barn, has about 42,000 square feet of useable floor space. It includes offices, greenhouses, animal rooms, agricultural engineering shops, conference rooms, laboratories, and support areas.

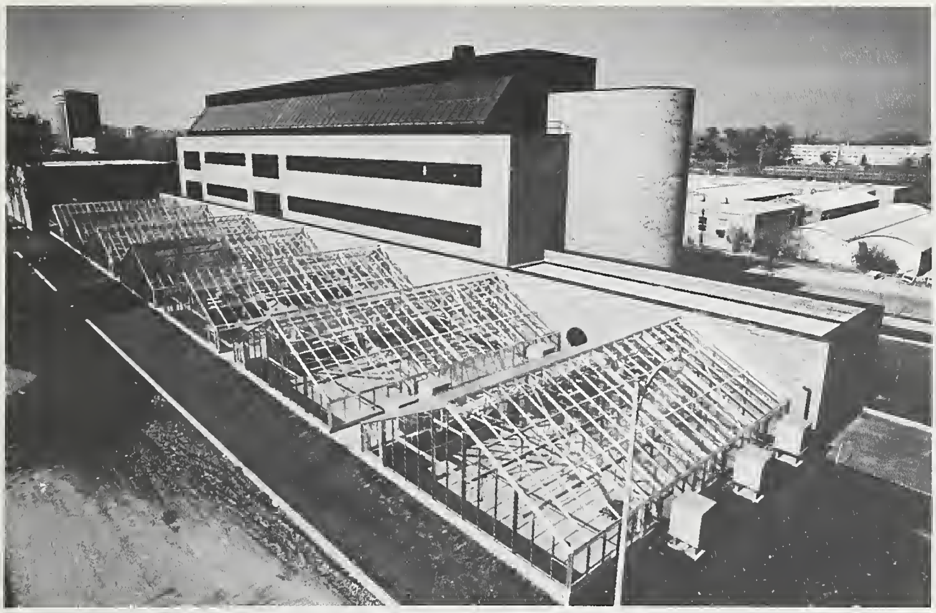
A solar collection system in the campus facility heats fresh air for the ventilating system. Engineers expect that fuel savings will pay for the solar collection system within 7 years.

Research at the campus and Prairie du Sac facilities is complemented by research at seven state agricultural experiment stations—New York, Minn-

Top:
Farm worker Josephine Lewandowski poses with Maggie, a high-producing dairy cow, and her offspring. Maggie donated embryos, which were transplanted to surrogate mothers. She and her calves, which are all full siblings, are members of the unique research herd at the center. (1181X1434-12)

Above:
ARS ruminant nutritionist Glen Broderick collects samples from the rumen of a lactating dairy cow. The cow was fed forage materials containing heavy nitrogen to reveal how protein from forages is used. (1181X1429-19a)

Right:
Liquid manure shoots into the air from a sprinkler to fertilize and water a pasture area. (1181X1442-17)



Left:
Dairy Forage Research Center's campus facility at the University of Wisconsin-Madison. (1181X1427-14a)

Above:
Dwayne Rohweder, Extension agronomist, University of Wisconsin, and R. J. Bula examine alfalfa to be harvested and used as experimental feed. (1181X1439-9)

esota, Pennsylvania, Michigan, Ohio, Iowa, and Missouri.

More than 70 percent of the dairy products of the Nation are produced in the north-central and northeastern states.

Most states have forage and dairy research scientists. Agricultural administrators, who planned the Center, formulated a cluster concept in which federal and state scientists can strengthen their research efforts by coordinating them with the Center's multidisciplinary research program. The concept provides an opportunity to plan research that meets the dairy industry's needs regionally and nationally with minimal use of public funds.

When the Center becomes fully operational, federal personnel at the Wisconsin facilities will include 6 dairy scientists, 6 plant scientists, 2 agricultural engineers, and about 20 support personnel, including secretaries and technicians. About 30 state personnel will work at the field facility.

The field facility is designed to accommodate about 300 high-producing cows and their replacement stock. Both grain and forage for the research herd will be produced on the 1,300 acres that ARS is leasing from the Department of Defense.

"With this size operation, our orientation will be to strengthen the economic stability of family dairy farms," says Bula.

Helping dairy farmers find ways to make the best use of their resources is what the research is all about. An example of resource stewardship may be seen in the Center's animal waste disposal system. It is designed to maximize nutrient recycling back to pastures and cropland. This will reduce needs for commercial fertilizers, which require large amounts of energy to produce.

Manure is moved by an automatic conveyor through gutters to a central location where pressure is applied to separate solids from the liquid. The solids are then used as bedding or fertilizer. Liquid wastes go to a holding pond, eventually to be pumped out and used to fertilize land.

By recycling manure to the land and exporting only milk from the farm, more total nutrients will remain in the soil than if the land were used to grow grain for commercial sales, says Bula.

Income from sales of milk produced at the Center is deposited into a reimbursable account used for expenses incurred in the Center's operations and research.

Some of the dairy cows that were formerly on University of Wisconsin experimental farms are now at the Center's field facility. When the herd size reaches 300 cows, milking in the eight-stall milking parlor will take about 5 hours.

Heifers that were purchased from farmers in southern Wisconsin have received embryo transplants in the Center's hospital area. The embryos came from registered cows with high production records. Since one donor cow, which has been superovulated by hormone injections, usually produces four or more embryos from one mating, embryo transplants will provide groups of genetically uniform animals for the research program.

Some of the surrogate mothers had calves last summer.

Center director Raymond Bula is located at the Dept. of Agronomy, Room 338 Moore Hall, University of Wisconsin, 1925 Linden Dr. West, Madison, WI 53706.—(By Ben Hardin, Peoria, Ill.)

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Building in Environmental Protection

Above:
Agronomist James Enlow, Soil Conservation Service, ARS management agronomist V. W. Matthias, and Extension agronomist Dwayne Rohweder, University of Wisconsin, examine vegetation stabilizing the banks of the liquid manure holding pond. The retension berm and standpipe behind them keep silt from washing into the Wisconsin River just behind the wooded strip. (1181X1438-20a)

Right:
Kim Cates, research assistant, University of Wisconsin, removes groundwater samples from test wells below the liquid manure holding pond. (1181X1441-24a)

Not only the cows but the land itself gets tender loving care at the new U.S. Dairy Forage Research Center at Prairie du Sac, Wisconsin.

"An environmental awareness permeated the planning of the facility," says Raymond J. Bula, Center director. "We made every effort to ensure that the Center's everyday operations would not only maintain environmental quality but enhance and improve it."

In drafting blueprints for the Center as a working farm, its planners had reason to be concerned about protecting and maintaining environmental quality. What was envisioned was a 300-head dairy herd, a milking complex, grazing pasture on about 400 of the Center's 1,300 acres of sloping land, and an overall esthetically pleasing layout bordering the Wisconsin River. All this could easily have added up to potential problems—erosion, overgrazing, nonpoint source pollution, lowered ground-water quality, and ruined landscape esthetics.

Nothing like that is happening. The land is carefully graded to minimize soil erosion and water runoff into the Wisconsin River. Heavily grassed waterways, used to control soil erosion during construction, are now fenced off and mowed, rather than grazed, so they will remain in good shape to check runoff.

Trees lining the river are fenced off and the area is reverting to its natural state—suitable for wildlife. This keeps cattle from treking to the river to drink and eliminates ruts causing soil erosion. Ground-water quality around the farmstead is monitored regularly, as it was during construction, to ensure its continuing good quality.

To handle animal waste, disposal systems were designed to recycle nutrients back to pastures and cropland, an added payoff that reduced the need for commercial fertilizers. Conveyors automatically remove waste from cows in the milking parlor/nursery/barn complex to a manure-processing room. Here solids are pressure separated from liquids. What is left is a neutral-smelling fibrous material that can be reused for feed, bedding, or fertilizer. Liquid wastes accumulate in a banked holding pond, fenced for safety.

Water and waste runoff from the pastures also are collected in the holding pond to eliminate any chance for nonpoint source pollution of the river. Periodically the liquid is pumped out and used to fertilize pastures and nearby cropland.

Visual esthetics of the scenic Wisconsin landscape are preserved at the Center. Nestled in a swale off the highway, the Center blends with the rolling countryside. The view from the river is screened by a border of trees.

As a result of environmental foresight, according to Bula, this new ARS research facility exemplifies what agricultural stewardship of the land is all about. "We've practiced what we preach."—(By Henry Becker III, Washington, D.C.)

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Soil Compaction May Sometimes Help

Compaction in selected areas along irrigation furrows can save water and energy by allowing irrigation water to be more evenly distributed in the field, according to an ARS study on the hydraulics of furrow irrigation systems.

Selective compaction allows infiltration rates along the length of a furrow to be controlled, and controlled infiltration rates make for a uniform distribution of water throughout the furrow. This is the key finding of the study which is being conducted at ARS's Snake River Conservation Research Center, Kimberly, Idaho.

The study, led by ARS agricultural engineer James A. Bondurant, has also shown that when infiltration is controlled, furrow lengths can be increased without increasing erosion. Longer furrows mean reduced irrigation equipment costs as well as less water and energy for irrigation.

Top:
A cast iron corrugating tool forms and compacts irrigation furrows by rolling through the soil. (0981X1090-23a)

Bottom:
James Bondurant checks flow meters in an irrigation test plot. Equal rates of water are measured into each furrow from gated pipe outlets. The furrows were made with various experimental compactors. (0981X1096-30a)

Compaction, which reduces infiltration rates, is generally looked upon by farmers as a practice to be avoided. The fear is that crops will not receive enough water and yields will suffer.

Bondurant points out though that when a furrow is irrigated, it takes some time for water to travel the furrow's length. This time difference causes nonuniform water distribution, the upper end of the furrow often receiving too much water and the lower end receiving too little. By the use of controlled compaction to vary the infiltration rate continuously down the furrow, irrigation water can be applied uniformly.

The savings in water, energy, and equipment costs from controlled infiltration rates and longer furrows should put furrow irrigation within economic reach of more growers, an important point given the rising costs of sprinkler systems.

Growers concerned about low infiltration rates may not have to worry. The lowest infiltration rates observed at the Snake River Conservation Research Center in the experimentally compacted furrows were still more than enough to meet crop needs. In fact, Bondurant believes that uniform water distribution in furrows through soil compaction might increase crop yields as much as 20 percent.

"All farmers have seen that on soil where a tractor has crossed, infiltration rates are lowered and water passes over much more quickly than surrounding soil that has not been compacted," says Bondurant. "This is a rather gross application of the principle we are using. What is needed now are guidelines for infiltration rates of different soil types and precision compacting tools that compact the soil to the necessary degree."

Currently, Bondurant and his fellow researchers are working with a corrugating tool that rolls through soil for compaction, rather than shearing like a conventional corrugation shovel. Rolling requires much less energy than shearing.

"We're getting good compaction at the bottom of our furrows, but not enough uniformity along the sides," says Bondurant.

Working with Bondurant on this project are W. Doral Kemper, soil scientist and Snake River Conservation Research Center director, and B. J. Ruffing, technician. All are located at the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, ID 83341.—(By Lynn Yarris, Oakland, Calif.)

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A Bug Too Snug
In a Skin It Can't Shrug

A new class of chemical compounds keeps the larva of the milkweed bug literally a prisoner in its own outer "skin," preventing the insect from molting into the next larval stage or into an adult.

"The new compounds have a different mode of action on the insect's own chemical system than other insect growth regulators we've tested," says Albert B. DeMilo, ARS research chemist, Beltsville, Md.

DeMilo synthesized about 70 variations (analogs) of chemical compounds called substituted thiosemicarbazones of 2-acetylpyridine. Colleagues Thomas J. Kelly, ARS physiologist, and Robert E. Redfern, ARS entomologist, then studied their effects on insect development and fertility. About 12 of the analogs kept the milkweed bug larvae locked in their old outer "skins," or cuticles, even though each had grown to normal size and produced a new cuticle under the old. The larvae literally rolled over and died several days after they were due to molt.

"These and other observations by my colleagues strongly suggest that the compounds have a novel effect on the insect's biochemistry, but we don't yet know what that effect is," explains DeMilo.

The thiosemicarbazones may have potential as insecticides if they are found active against serious insect pests. (The milkweed bug, a North American insect, is not a serious pest, but is useful in research because it is easily reared in the laboratory.) In preliminary tests, the active analogs caused some molting and growth problems in the larvae of two widely unrelated types of insects—fall armyworms and houseflies—but more testing is needed, DeMilo says.

Top:
Bloodlike fluid is drawn from a milkweed bug treated with a molt inhibitor. The fluid will be analyzed to determine the levels of hormones that affect molting. (0981W1245-9a)

Bottom:
Albert DeMilo purifies a synthetic chemical that inhibits molting. (0981W1246-18)

Also, analogs that work at far lower doses would be needed. A dose of 10 micrograms of the most active analog was required to kill the milkweed bug larvae. However, that dose is still 1,000 times higher than the active dose of a commercial insecticide, diflubenzuron (Dimilin), which also acts on the larval stage. Diflubenzuron kills a wide variety of insects by interfering with the formation of a new cuticle.

The search for more effective analogs is continuing, and with a clearer direction. DeMilo now knows which areas of the molecule can be modified to improve its biological effectiveness so he will concentrate his future efforts in this direction. So far the syntheses have been straightforward, requiring low-cost starting chemicals and only three to five steps. Overall yields of the pure compounds have ranged from 50 to 60 percent.

DeMilo said he and his colleagues decided to explore the thiosemicarbazones in their screening program because they were aware that similar compounds had antifertility effects in screwworms and boll weevils. "Although we found no antifertility effect in the milkweed bug, we did produce a new wrinkle in its molting process," he says.

Whether or not the thiosemicarbazones will become useful for insect control is still to be determined, but DeMilo says they already have proven useful in studying the role of molting hormones in the bug's normal development.

Albert B. DeMilo is located at the Insect Reproduction Laboratory, Bldg. 306, Beltsville Agricultural Research Center-East, Beltsville, MD 20705.—(By Judy McBride, Beltsville, Md.)

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Tomato Ringspot in Strawberries

Tomato ringspot virus has been detected in four commercial cultivars of strawberries and may be responsible for the widespread, unexplained sudden death syndrome afflicting at least one variety of strawberry plants in the Pacific Northwest.

ARS plant pathologist Richard H. Converse, Corvallis, Oreg., using the ELISA virus detection technique he helped popularize (see *Agricultural Research,* April, 1978), has found tomato ringspot virus in strawberry cultivars Olympus, Lassen, Puget Beauty and Sequoia. Present throughout the Pacific Northwest and California, tomato ringspot virus is transmitted by American dagger nematodes.

"Growers should be warned not to plant strawberries until their fields are tested for dagger nematodes," says Converse. "If the nematodes are present, fields must be fumigated before planting; otherwise, crop losses may result."

Tomato ringspot virus has been difficult to detect in strawberries. Infected plants are often dwarfed and may die early, but in general, they display no unique symptoms. ELISA (enzyme-linked immunosorbent assay), however, is 100 times more sensitive than previous virus-detecting techniques and has enabled Converse to make rapid, positive identifications.

"It's been demonstrated now that under natural field conditions, tomato ringspot virus can cause a severe and hitherto unrecognized disease in several commonly grown strawberries, and that a range of symptoms result, many resembling those caused by aphid-borne viruses," says Converse.

Converse believes that tomato ringspot virus is probably common in strawberries but has not been associated with crop losses because, in addition to a lack of recognizable symptoms, natural field transmission of the disease by dagger nematodes is slow and erratic.

No commercial cultivars currently popular are known to be immune to

Above Left:
Technician Kathy Kowalczyk prepares strawberry cultures for grafting tests. Before ELISA was developed, this was the standard method of detecting all viruses in small fruits. (0381X320-17)

Above:
With ELISA (enzyme-linked immunosorbent assay), a plant leaf that may have tomato ringspot virus is treated with a buffer. Next it will be homogenized and exposed to an antiserum capable of recognizing the virus. (0381X319-28)

Left:
The ELISA process is performed inside these small transparent trays. The color yellow in the final step indicates that tomato ringspot virus is present. (0381X321-9)

tomato ringspot virus, but according to Converse, immunity exists in some strawberry cultivars. ELISA, he says, will help evaluate new strawberry lines for immunity to tomato ringspot virus infection and help state certification programs screen commercial nursery stocks for tomato ringspot presence.

A mysterious sudden death syndrome causes Olympus strawberries to wither and die as if infected with verticillium wilt. However, tests on such plants often fail to detect the presence of verticillium. The collapse of Olympus plants in Converse's tomato ringspot test fields resembled this sudden death syndrome, and Converse is now investigating the possible link.

Richard H. Converse is located at Room 1067, Cordley Hall, Oregon State University, Corvallis, OR 97331.—(By Lynn Yarris, Oakland, Calif.)

Trickle Irrigation Boosts Tomato Yields

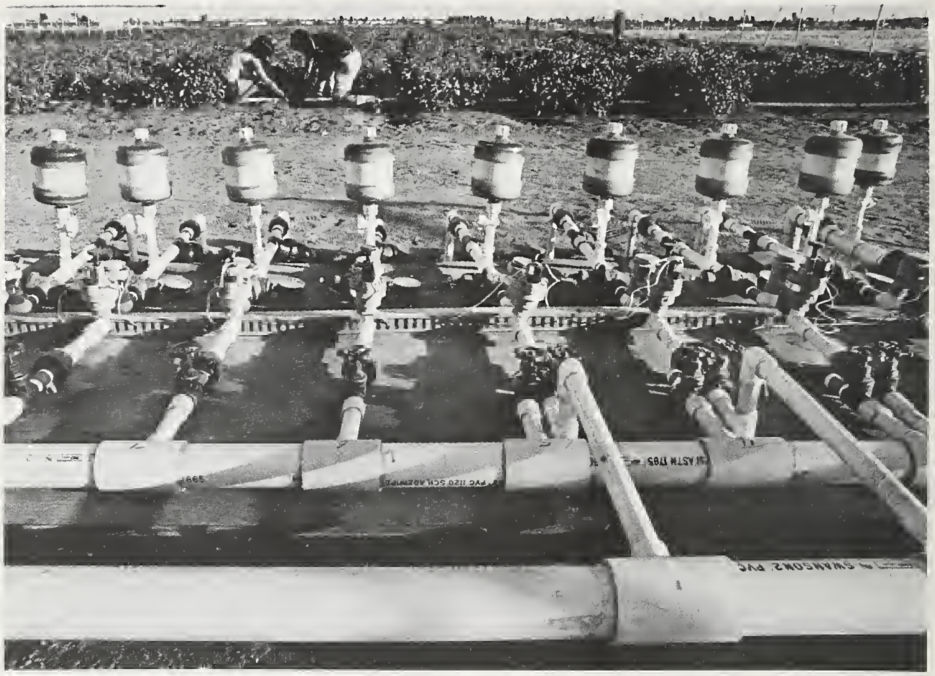
Nearly 59 tons per acre of marketable processing tomatoes were grown this year at Fresno, Calif., in a study using permanently installed, automatically controlled subsurface trickle irrigation systems.

The yield is more than twice the 24-ton average yield for California, although many growers exceed that average by some tonnage. One commercial grower near Fresno reported 31 tons per acre on 900 acres using 33 inches of water per acre. The average consumptive water use for tomatoes in the state is about 24 inches. ARS researchers produced the 59-ton yield with only 25.5 inches of applied irrigation water. Some growers use sprinkler irrigation on tomatoes, but most have furrow systems. None, as yet, use permanent subsurface trickle irrigation.

Janet L. Rose, ARS agronomist, assisted by Rebecca L. Chavez and Donna J. Robb, both research technicians, did the study in cooperation with California State University, Fresno.

The researchers compared three methods of irrigation. The first method is based on electronic feedback from a weather station that feeds readings of solar radiation, wind speed and direction, temperature, and humidity into a computer. The computer then calculates how much water has been "lost" through evapotranspiration. That information goes into an irrigation controller that meters water through the subsurface lines by several small "pulses" throughout the day. In a sense, the system replaces water almost as soon as it is used by the crop, keeping the soil moisture at a level ideally suited for the tomatoes.

The second method relies on direct electronic soil moisture readings that go into the irrigation controller. The early part of the year the researchers used periodic tensiometer readings and fed those readings into the controller. During the latter part of the season, however, they used the electronic soil moisture sensors placed near the subsurface lines. Those sensors were



Top:
The main manifold for the buried trickle irrigation system meters out water to the test plots. (0781X885-22)

Bottom:
Using climatic data from the nearby weather station, technician Becky Chavez programs the irrigation controller to deliver the right amount of water to test plots. (0781X886-13)

Right:
Janet Rose inserts leaves into a leaf area meter to determine differences in plant growth caused by various irrigation treatments. Leaves shown here are cotton, but this meter is also used to measure tomato leaves. (0781X887-20a)

Above:
Trickle irrigation tubing is buried under the tomato plants so that it does not have to be installed and picked up each year. (0781X885-14)

Left:
Becky Chavez checks the tensiometers, which measure soil moisture. (0781X885-32)

hooked up directly to the irrigation controller, which metered water to the tomato plants when the sensors indicated that soil moisture had fallen below a preset amount.

The third method, furrow irrigation, much like what growers are currently using, was used as a control.

Plots irrigated with buried trickle irrigation lines based on weather station data yielded from 43 to 59 tons per acre of marketable tomatoes with applied irrigation water ranging from 19.2 to 25.5 inches.

Plots irrigated similarly but based on direct soil moisture data yielded from 50 to 56 tons per acre with applied irrigation water ranging from 24.0 to 40.5 inches.

The furrow control treatment yielded 40 tons per acre from 24.7 inches of water.

The subsurface trickle lines are buried about 18 inches below the surface and should have a 5- to 10-year lifespan. Plowing, seeding, and other cultural practices should offer no problem with lines at that depth, says Claude J. Phené, soil scientist, who directs ARS's Water Management Research Laboratory at Fresno.

Phené says that the project has had no trouble with roots clogging the irrigation lines, and that future studies will include fertilizing and fumigating through the subsurface lines.

Phené, who is enthusiastic about both the weather station and soil sensor methods, thinks that control of irrigation systems based on the soil sensor method is the least complicated and that "we can have even better yields next year." He says that the 40 inches of water applied on one of the plots was a result of planned overirrigation and that future studies will reduce that amount considerably.

"High frequency irrigation can be controlled accurately by a soil sensor in the root zone of most row crops. The sensor can be used to maintain a portion of the root zone at a nearly constant soil moisture, thus minimizing plant water stress.

"Trickle irrigation systems controlled by a single soil sensor can be used effectively to replace water lost from the root zone consumptively. Similar results obtained earlier in the southeastern United States under various soil and weather conditions implied that this control concept and method should easily be adaptable to soils with greater water storage capacity and for areas with more predictable climatic conditions such as found in semiarid irrigated agriculture not subjected to frequent rainfalls," Phené says.

Janet L. Rose is located at the USDA-ARS Water Management Research Laboratory, 5544 Air Terminal Drive, Fresno, CA 93727.—(By Paul Dean, Oakland, Calif.)

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Harvesting Alfalfa Late

Under the right conditions, late-season harvesting of alfalfa does not damage the stand. (Photo courtesy of Grant Heilman)

Any late-season harvesting of alfalfa has been "against the rules" for many years. But recent studies show that the rule can be violated without damaging alfalfa stands or yields, provided the conditions are right.

Research agronomist Gordon C. Marten at St. Paul, Minn., made third cuttings at three different periods—Aug. 26 to Sept. 3, Sept. 15 to 19, and Sept. 30 to Oct. 15—over three growing seasons. The first two cuttings were at early bloom, about June 1 and July 15. He says the early second cut (by July 15) is one condition that allowed late third cuts to be successful.

He also says that the results show "harvest of the third crop anytime during September or early October can allow long stand persistence and high hay yields in the northern states, but only if soil fertility is adequate, winterhardy varieties are planted, and adequate snow cover exists during the coldest parts of the winter."

Marten was testing Vernal alfalfa on silt loam with a pH of 6.7 under a fertilization program that maintained availability of at least 300 pounds of potassium and 50 pounds of phosphorus per acre. Snow cover averaged 4 to 12 inches during the coldest parts of the winters.

He also tested three cutting height combinations—three cuttings at 2.8 inches, three cuttings at 5.5 inches, and the first two at 2.8 and the third at 5.5 inches. Neither cutting height nor date influenced crude protein content or digestibility. However, the high clipping (three cuttings at 5.5 inches) did reduce yields by about 9 percent.

"There were no differences in appearance among the plots in terms of ground cover and plant vigor after the 3 years of treatments," Marten says. Standard treatment of all plots in the fourth season produced no yield differences as a result of the previous treatments.

"The research indicates that farmers need not always give up a late third cutting of alfalfa when weather or other labor demands prevent them from cutting by early September," Marten added. This does not mean that the old rule is passé; it still applies under many conditions. Rather, it means that the excellent manager can get by with violating the old rule if conditions are right.

More research is needed to determine whether these results will hold up with other varieties in other environments and whether a fourth cutting in September or October under the same conditions will affect yields and persistence, he said. Very likely a fourth cutting in late autumn will interfere with long-term persistence of the alfalfa stand. However, Marten's third cutting results have been repeated in other recent Minnesota tests at two additional locations.

Gordon C. Marten is located in Room 404 Agronomy Bldg., University of Minnesota, St. Paul, MN 55108.—(By Ray Pierce, Peoria, Ill.)

Rapid Analysis for Food Fiber

Above:
Karl Norris holds a sample of ground grain ready to be analyzed for fiber content in the near-infrared equipment behind him. (0581W557-13)

Right:
Doris Baker fills a sample holder with ground grain for fiber analysis. (0581W560-26)

Food fiber can now be measured quickly and accurately using near-infrared reflectance (NIR) analysis, a technique originally developed for measuring moisture in grains and oilseeds. NIR can identify starch, sugar, protein, water, and oil, and will measure fiber in breakfast cereals. Fiber can also be measured in animal feeds, grains, and forages.

Karl Norris, ARS agricultural engineer at the Instrumentation Research Laboratory, Beltsville, Md., originally developed NIR spectroscopy in 1963.

The analysis takes less than 3 minutes, compared to the 24 hours for the neutral-detergent methods currently recommended by the American Association of Cereal Chemists. NIR analysis is clean, easy to perform, and nondestructive, so the same sample can be checked repeatedly. By contrast, neutral-detergent analysis requires several chemicals and trained personnel, and completely breaks down the sample being tested.

For each sample Norris takes many measurements at a rate of 25,000 per second. A computer coordinates the measurements, performs computations, and fits the readings into a standard curve. In this way, readings are translated into the amount of fiber or other substances present in the sample tested.

With ARS research chemist Doris Baker of the Nutrient Composition Laboratory, Norris compared NIR and neutral-detergent analyses of 123 cereal samples. The correlation coefficient between NIR and neutral-detergent analyses was close to perfect: 0.99.

Today, three companies are marketing NIR analysis equipment that can analyze for oil, fiber, protein, and moisture. The procedures are easily automated, so analyses can be done during the manufacturing process or on final products to guarantee the content.

In the field of agriculture NIR is used today mainly in analyzing the protein content of grains in state and federal regulatory laboratories and in industry's quality control laboratories. Norris says that NIR techniques may develop into a general-purpose tool for analyzing the composition of all agricultural products.

Although ARS is not exploring the industrial applications of NIR, Norris speculates that many possibilities exist for industry—in the pharmaceuticals to analyze the composition of drugs, in medicine to analyze the fat content of patients, in the petroleum industry to analyze petrochemicals, in the fabric industry to measure the contaminants in cotton and wool, and even to analyze the proportions of wool and other natural fibers to artificial fibers.

Karl Norris is located in Room 104, Bldg. 002 and Doris Baker in Room 105, Bldg. 161, Beltsville Agricultural Research Center, Beltsville, MD 20705.—(By Ellen Mika, Beltsville, Md.)

Soil scientist Paul Lawless measures soil moisture with a gamma ray probe. The measurements are compared with microwave disc measurements from high above the crop. (0881W1029- 30a)

In a second "ground truth" test, Lawless takes a soil sample to test its water content. The disc-like moisture sensor also measures the sample's water content, and the results will be compared. (0981W1248-20a)

Sensing Soil Moisture by Satellite?

A new moisture-sensing device that can "see" soil moisture as deep as 6 inches below the surface of the earth has been developed in a cooperative effort between ARS and the National Aeronautics and Space Administration (NASA). Remotely sensed information on soil water could help farmers manage irrigation better, says Thomas J. Jackson, ARS hydrologist, Beltsville, Md.

The moisture-sensing work is part of AgRISTARS (Agricultural Resource Inventory Survey Through Aerospace Remote Sensing), a cooperative effort among USDA, NASA, the National Oceanic and Atomospheric Administration, the Department of the Interior, and the Agency for International Development. (See *Agricultural Research,* November, 1980.) Other projects of AgRISTARS are related to detecting crop stress, estimating crop production in the United States and foreign countries, determining land use practices, and monitoring the effects of pollution on freshwater environments.

Currently, farmers plan irrigation by checking appearance of the crop and soil, by using computer models, or by checking soil moisture with water-detecting probes that are inserted into the ground. But the extensive sampling needed to get reliable information by these methods is costly and time consuming.

Thomas J. Jackson (left) and James R. Wang, of NASA, check moisture content of corn. They are working on methods of determining soil moisture content through various cover crops. The truck-mounted moisture sensor is above them in the background. (0881W1030-20a)

The project's goal, according to Jackson, is to develop a remote water-detecting system that could sense soil moisture and crop conditions from satellites in Earth orbit; reaching that goal could take 15 to 20 years. "We hope to have a system that could provide daily measurements for individual farms over large areas," Jackson says. Such data would be a source of accurate information for irrigation managers and others—for example hydrologists—interested in how much water is available in the soil.

Jackson and colleagues Thomas J. Schmugge and James R. Wang (both of NASA's Goddard Space Flight Center) are evaluating a microwave detector that looks like a radar dish or disc mounted high above a truck. In explaining how the device works, Jackson says, "Energy from the sun is absorbed by the soil. The amount of energy emitted by the soil at microwave wavelengths depends primarily on the amount of water in the soil's surface layer. The sensor measures that emitted energy." The scientists also are developing ways for extrapolating from the surface measurements how much water is available in the entire soil profile.

In tests of the moisture detector's accuracy, the disc is mounted on the truck and measures moisture of plots with various cover crops. The results are compared with results of several standard tests of soil-water content made from the ground.

If the moisture-sensing device is to be useful in irrigation scheduling, however, it must provide frequent, repetitive coverage—like that from regular passes of aircraft or orbiting satellites. Also, the information must be made available to users almost immediately, before changes in crop conditions, weather, or soil water content make it obsolete.

An aircraft-mounted moisture sensor has been used in small-scale studies since 1978. These preliminary tests were done at the ARS experimental watershed stations in Chickasha, Okla., Tifton, Ga., and Taylor Creek, Fla. The moisture-detecting equipment was attached to aircraft that flew at a 1,000-foot altitude over the test areas. Results showed that the sensor works equally well over diverse geographic areas.

Now, systematic aircraft testing is planned. Measurements made from aircraft carrying the device will be compared with "ground truth" tests—measurements taken at the same time and place on the ground. The regularly collected data will be tested in the field over several years.

Jackson reports that the Soviets are already using microwave sensing of soil moisture for irrigation management. In the USSR, three aircraft monitor a 250,000-acre area weekly. The system was tested in 1977 and 1978 and has been used regularly since 1979, but it is less versatile than the system ARS and NASA scientists are working on now.

Others besides irrigators might use the remotely-sensed soil moisture data from the new system. For example, the Army Corps of Engineers may be able to use the information for improving flood forecasts, and the Soil Conservation Service might use it in preparing weekly drought maps of the United States, which are now based primarily on qualitative data.

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Agrisearch Notes

Rice Weevil Lure Found. Male rice weevils produce a scent or attractant to both sexes of their species. This discovery may lead researchers to success in their search for ways to curb losses of stored cereal grains throughout the world while minimizing the use of insecticides.

"Future isolation, identification, synthesis and commercial development of the attractant, or aggregation pheromone, could advance integrated pest management schemes against rice weevils," says ARS entomologist Wendell E. Burkholder, Madison, Wis.

"The grain weevils account for hundreds of millions of dollars in losses annually in inventories of rice, wheat, and other cereal grains," says Burkholder.

In conducting their experiments, graduate student Joel K. Phillips of the University of Wisconsin and Burkholder obtained their evidence of attractants on paper discs taken from vials that had held either a male or a female weevil. Then they tested the relative attractant strengths of the discs or of solvent extracts from the discs using two bioassay procedures.

Both male and female weevils were attracted preponderantly to discs from vials that had contained a male weevil, Burkholder says.

Using a conventional desiccator bioassay procedure, the scientists saw attracted weevils moving in tight loops and circles beneath suspended male discs, occasionally rearing up and thrashing at the discs with their forelegs.

The researchers devised a pitfall bioassay procedure which they used to further observe the weevils. During this procedure most of the weevils crawled into vials that contained male discs and grain in preference to vials that contained female discs and grain, or just grain.

Solvent extracts from discs used in the new procedure provided the scientists with results similar to what they obtained using the discs.

The scientists are continuing their studies to isolate and chemically identify the aggregation pheromone.

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Plant Inhibitors in Fescue. Future varieties of tall fescue may grow more compatibly with birdsfoot trefoil or red clover than present varieties. That's because researchers now are focusing on a phenomenon called allelopathy.

Allelopathic substances, or plant compounds known as allelochemics, can inhibit growth of other plants and animals. ARS agronomists Elroy J. Peters and Arthur G. Matches, Columbia, Mo., and their University of Missouri colleagues found that breeding lines of tall fescue differ in their allelopathic effects.

The research team has used water to leach allelochemics from leaves of fescue lines, providing crude extracts for a variety of expeirments. Kien T. Luu, a graduate student, has gone a few steps further and tentatively identified some of the growth inhibitors.

"Extracts from fescue foliage sampled from June through September are less potent than extracts from January through May samples," Peters says. "We've also found that nitrogen fertilization increases the allelopathic effects of tall fescue."

In one experiment the scientists treated birdsfoot trefoil and red clover seeds with extracts from six tall fescue breeding lines. Within 2 weeks only 41 to 56 percent of the treated clover seeds germinated, depending on which extract was applied, while 82 percent of nontreated seeds germinated. Germination of treated birdsfoot trefoil seeds ranged from 29 to 53 percent while the nontreated seeds' germination percentage was 66.

Perhaps not all allelopathic effects of fescue are bad for the farming business, though.

"If you don't like having crabgrass in your meadows, some future varieties of fescue may be just the ticket," says Peters.

Some scientists have suggested that weed-inhibiting allelochemics might also confer to plants some resistance to diseases and insects.

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